

THUMPER – A 200 MICRON CAMERA FOR THE JCMT

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ABSTRACT

We are building a **Two HUndred Micron PhotometER** (THUMPER) for the 15-m James Clerk Maxwell Telescope in Hawaii. Taking advantage of a narrow atmospheric window that opens up at this wavelength on high, dry sites, THUMPER will make continuum observations at 200 μ m from the ground with unprecedented 7'' angular resolution. THUMPER will go into operation in early 2003, initially as a PI instrument, but with the aim of handing it over to the community later on.

The focal plane comprises a hexagonal close-packed array of seven stressed Ge:Ga photoconductors fed by individual Winston cones and operating at 3.7K. The detectors are read out by TIA amplifiers using cold JFET pairs. THUMPER is being designed to work in parallel with SCUBA using a dichroic beam-splitter.

The data will be handled by the SCUBA data acquisition system, enabling all SCUBA users to see the THUMPER instrument as an additional short-wavelength sub-mm array. The instrument is planned to be in operation by early 2003.

INTRODUCTION

Observations in the Far Infrared (FIR) are crucial to our understanding of many important aspects of the Universe, from studies of star formation in our Galaxy to studies of the origin and evolution of galaxies. Most of the energy in the extra-galactic background emerges in the FIR and sub-mm, with the peak occurring at around 200 μ m.

Because the flux is dependent on both the source temperature and density it is crucial to try to disentangle the two, which requires observations of the highest possible angular resolution. To date, the highest resolution FIR data are from a limited number of sources observed by the Kuiper Airborne Observatory, with its 90-cm aperture. Within this decade we will obtain much higher resolution data with SOFIA and HERSCHEL. However, even these two observatories will have resolutions which fall far below the resolution we currently enjoy in the sub-mm with telescopes like the JCMT and the CSO.

THUMPER is a novel instrument which will attempt to take advantage of the narrow atmospheric window which opens up at 200 μ m under the best atmospheric conditions. As Figure 1 shows, this window has a peak transmission of about 20% when the precipitable water vapour falls to 0.5mm¹.

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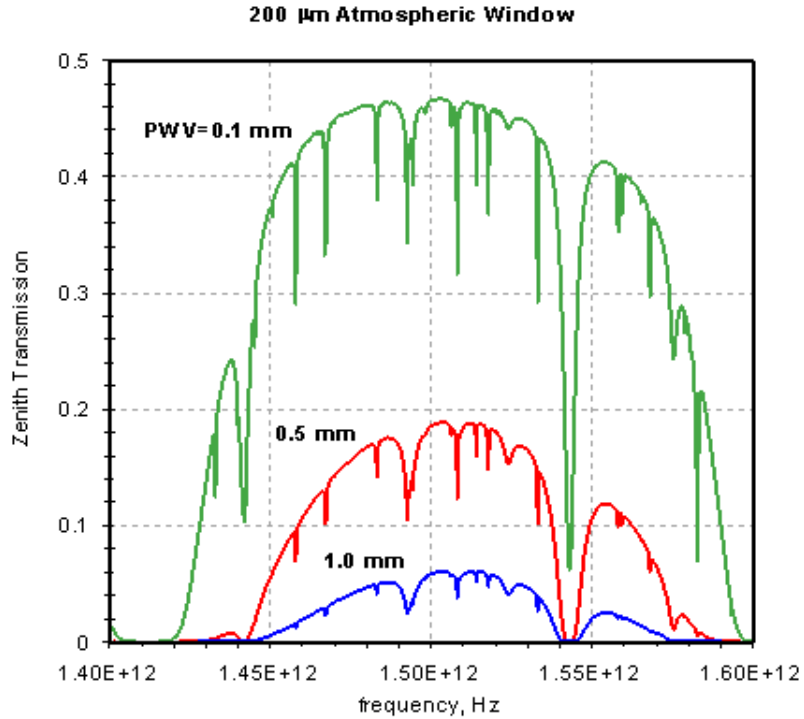


Figure 1: The predicted 200 μ m atmospheric transmission for different values of precipitable water vapour (from [1]).

THUMPER is being designed to work on the JCMT in parallel with SCUBA and will take images with a 7'' resolution, the same as SCUBA's 450 μ m channel. We will take advantage of spare data channels in the SCUBA Data Acquisition System (DAQ), and analysis will be done using the standard SCUBA User Reduction Facility (SURF) software.

THUMPER'S OPTICAL DESIGN

One of the primary design requirements of THUMPER is that its operation does not affect in any way the operation of SCUBA. To this end THUMPER's warm optics will include a dichroic beam splitter reflecting the 200 μ m radiation to our detectors whilst allowing the radiation longwards of 300 μ m to continue unhindered to the SCUBA detectors.

A series of 3 powered and 1 flat mirror on the SCUBA optical bench will bring the beam into the THUMPER cryostat. On the cold surface a powered mirror and a flat will bring the beam into the Winston cones.

Figure 2 shows the layout of the cold surface. A band-pass filter will be placed directly in front of the Winston cones, with blocking filters and a correcting plate to correct for aberrations placed on a snout on the Helium shield.

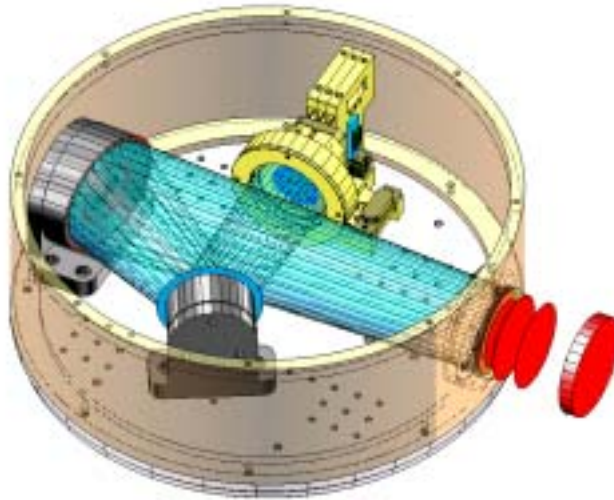


Figure 2: THUMPER cold surface optics and Helium shield. Projecting from the Helium shield on a snout will be a corrector plate and blocking filters. The bandpass filter will go directly over the Winston cones.

THUMPER'S DETECTOR ARRAY

THUMPER will use an array of 7 hexagonally packed stressed Ge:Ga photoconductors fed by individual Winston cones. The spacing of the detectors will be matched to that of the SCUBA 450 μ m array, and we are overmoding the Winston cones at 200 μ m in order to increase our sensitivity and match the resolution of the 450 μ m data.

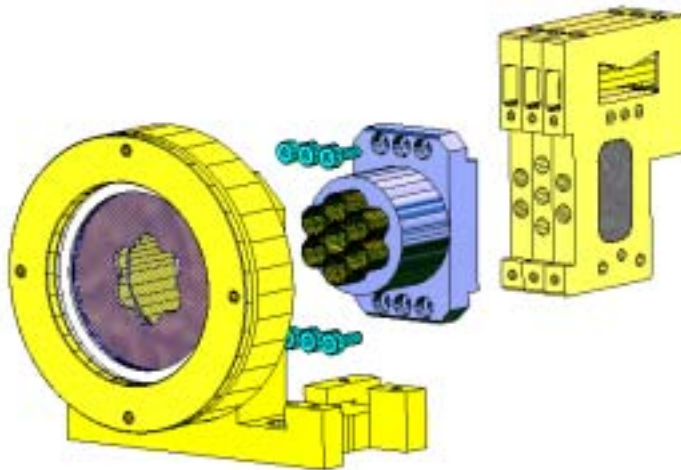


Figure 3: An exploded view of the THUMPER Focal Plane Assembly. The stressing blocks are at the back, in the middle is the Winston cone assembly, and in front is the band-pass filter mount.

The detectors will be read out by Transimpedance amplifiers (TIA) using cold JFET pairs mounted on the liquid Nitrogen shield, with each detector being individually biased for optimum signal-to-noise.

Figure 4 shows a graph of how we have moved the wavelength of peak response into the 200 μ m window by applying stress to our test crystals and in Table 1 we summarise the measured test detector characteristics.

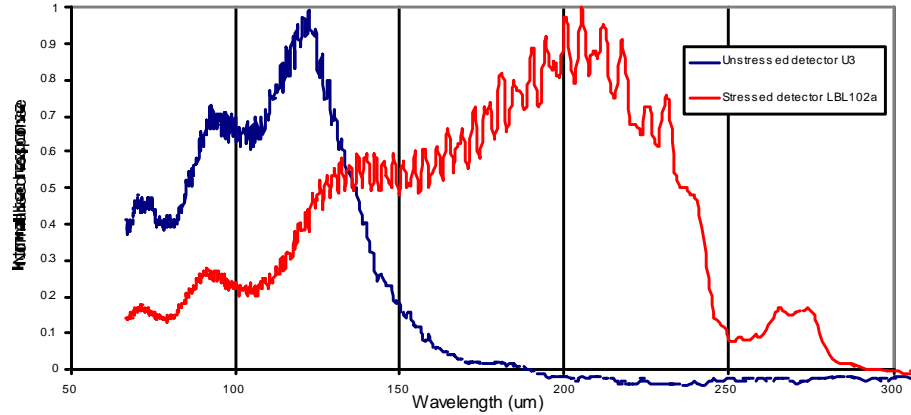


Figure 4: The shift in peak response of one of our test crystals with applied stress.

Table 1: Summary of test detector characteristics

Temperature of Operation	3.7K
Feedback Resistance	5M Ω
Optimum Bias	10mV
Responsivity at optimum bias	30A/W
DQE at Optimum Bias	15%
Dark current at 3.7K	5×10^{11} e/s
RQE Gain Product	0.2
Noise Contributions:	
Photon	350 nV/ $\sqrt{\text{Hz}}$
Feedback Resistor	26 nV/ $\sqrt{\text{Hz}}$
Detector Resistance	4 nV/ $\sqrt{\text{Hz}}$
JFETs	150 nV/ $\sqrt{\text{Hz}}$
Dark Current	740 nV/ $\sqrt{\text{Hz}}$
Detector Impedance	100 k Ω

THE THUMPER CRYOSTAT

In order to minimize the support necessary for THUMPER we plan to run the detectors at unpumped liquid Helium temperatures, which at the summit of Mauna Kea corresponds to 3.7K. Because of this relatively high temperature we will actually be dark noise limited (as shown in Table 1), but currently the level of funding and support to operate at a lower temperature is not available. The cryostat is being designed to give us a long liquid Helium hold time, our current thermal models suggest a hold time for our 6.0 litre Helium reservoir of in excess of 30 days. The 6.5 litre Nitrogen reservoir will be kept topped up via an auto-fill system similar to that used by SCUBA.

REFERENCES

- 1 Araujo, H. et al 2002, "Assessment of the 200 μ m Atmospheric Window for Ground Based Astronomy", International Journal of Infrared and Millimeter Waves, vol. 22, no. 7